# HIGH-FREQUENCY WAVEGUIDE AND MANUFACTURING METHOD THEREOF

## BACKGROUND OF THE INVENTION

### Field of the Invention

Sub B1

The present invention relates to a high-frequency waveguide and a method of manufacturing it, and particularly to a waveguide through which electromagnetic waves lying in a microwave, a millimeter-wave and a submillimeter-wave bands propagate, and a manufacturing method thereof.

### Description of the related Art

Sub B2

As a waveguide for allowing electromagnetic waves (hereinafter called "high-frequency waves") lying in a microwave, a millimeter-wave and a submillimeter wave bands to propagate, a hybrid waveguide comprising a combination of wave guides, metals and a dielectric has been used. An NRD (nonradiative dielectric) guide with a dielectric interposed between two metal plates has been used as a waveguide in which metals and a dielectric are utilized in combination. As the known references, for example, there are known IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. MTT-29, NO. 11, NOVEMBER 1981, PP. 1188-1192, and IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. MTT-32, NO. 8, AUGUST 1984, PP. 943-946.

Sub B3

While the NRD guide has the feature that no radiation loss is produced at a bent portion of a waveguide, a propagation loss increases because it is used in the neighborhood of a cutoff frequency of the waveguide. In addition to this, a waveguide using a photonic band crystal structure has been placed under study as a waveguide low in radiation loss.

The photonic band crystal structure includes an artificial crystal having a dielectric periodic structure having a high dielectric constant ratio and allows the occurrence of such an event that the propagation of energy is prohibited, at a given

energy region, in the same manner as the case where the crystal controls electrons. The formation of a periodic-structure disturbing portion at part of the photonic band crystal structure makes it possible to cause energy to propagate through such a defective portion alone, whereby it can be formed as an energy propagation path.

As the known reference wherein the photonic band crystal structure is formed as a waveguide for optical transmission, there is known NATURE, VOL. 386, 13 MARCH 1997.

Further, Japanese Patent Application Laid Open No. 2000-352631 describes photonic crystals and a method of manufacturing the same. This shows one wherein cylindrical dielectrics arranged in a triangular lattice form to increase a mechanical strength are utilized in combination with perfect band gaps comprising dielectrics two-dimensionally arranged in a honeycomb lattice form as photonic crystals used in the field of the optical transmission.

Furthermore, Japanese Patent Application Laid-Open No. Hei 11(1999)-218627 describes a photonic crystal waveguide and a method of manufacturing it. This shows one formed with a slab optical waveguide formed of quartz glass or a polymeric material on a silicon substrate as a photonic crystal waveguide used in the field of optical communications. The slab optical waveguide is one wherein materials different in refractive index are arranged on both sides of a centrally-provided optical waveguide area in the form of a triangular lattice or a hexagonal lattice to provide refractive index variation areas. However, these photonic crystal waveguides are techniques related to optical waveguiding.

Fig. 7 is a perspective view of a conventional high-frequency waveguide based on a photonic band structure.

In Fig. 7, reference numeral 100 indicates a high-

frequency waveguide, reference numeral 102 indicates a dielectric such as ceramic, and reference numerals 104 respectively indicate air columns whose arrangements in this air constitute a photonic band crystal structure. Reference numerals 106 indicate metal plates bonded to each other at both end faces of the dielectric 102 as viewed in the direction orthogonal to the air columns 104. In Fig. 7, the metal plates 106 are hatched as being not intended to indicate their sections but indented to clearly define a relationship of position between the two metal plates 106 and the dielectric 102.

Fig. 8 is a cross-sectional view of the high-frequency waveguide 100 as viewed from a section thereof taken along line VIII - VIII of Fig. 7. The section taken along line VIII - VIII corresponds to a section orthogonal to each of the air columns 104.

In Fig. 8, reference numerals 108 indicate high-frequency reflecting areas, and reference numeral 110 indicates a high-frequency propagation area.

When a high-frequency wave propagates through the high-frequency waveguide 100, each of the high-frequency reflecting areas 108 prohibits the propagation of a high-frequency wave corresponding to the photonic band crystal structure. However, since the high-frequency propagation area 110 has no air columns 104 and results in a defect of the photonic band crystal structure, the high-frequency wave can propagate through this portion.

When an electromagnetic wave propagates through the high-frequency propagation area 110, a high-frequency current flows due to an omnidirectional magnetic field as viewed in the tangential direction of each metal plate 106. This results in transmission loss of Joule's heat. However, since the transmission loss decreases with an increase in frequency in a

mode in which the magnetic field principally has a high-frequency transmission direction of the high-frequency propagation area 110, it normally presents no problem.

However, since the high-frequency propagation area 110 makes use of a dielectric high in dielectric constant, a dielectric loss increases significantly.

Fig. 9 is a perspective view of a conventional high-frequency waveguide based on another photonic band structure. The same reference numerals as those shown in Figs. 7 and 8 respectively indicate the same or equivalent ones. Even in the case of the description of the following drawings, the same reference numerals respectively indicate the same or equivalent ones.

Reference numeral 112 indicates a high-frequency waveguide, and reference numerals 114 and 116 respectively indicate dielectrics such as ceramic.

Fig. 10 is a partly sectional view of the high-frequency waveguide 112 as viewed from a section thereof taken along line X - X of Fig. 9, and Fig. 11 is a cross-sectional view of the high-frequency waveguide 112 as viewed from a section thereof taken along XI - XI of Fig. 9, respectively.

In the high-frequency waveguide 112, high-frequency reflecting areas 108 are disposed in parts as two independent portions in which air columns 104 are regularly arranged in the dielectrics 114 and 116. A high-frequency propagation area 110 is defined as space filled with air. Therefore, a dielectric loss at this portion can be reduced.

However, in either case of the high-frequency waveguide 100 and the high-frequency waveguide 112, it is difficult to carry out the work of forming the desired air columns 110 in the dielectrics. Since the high-frequency propagation area 110 is defined in the space in the high-frequency waveguide 112, it is

difficult to carry out dielectric-removing processing. This is not suited to mass production.

On the other hand, the paper Vol. J84-C No. 4 pp. 324-325, April 2001 issued by the Institute of Electronics, Information and Communication Engineers has described a photonic crystal waveguide wherein columnar bars in which alumina is covered with styrofoam, are provided in a triangular lattice array. However, this will cause an increase in loss.

**Summary of the Invention**

The present invention has been made to overcome the above-described drawbacks and disadvantages of the related art. It is an object of the present invention to provide a high-frequency waveguide which is low in loss, simple in structure and low in cost.

According to one aspect of the invention, there is provided a high-frequency waveguide according to the present invention comprising: a first high-frequency reflecting wall wherein dielectric bars of predetermined lengths, which respectively comprise a plurality of dielectric constant-different columnar bodies concentrically disposed so that their dielectric constants on the axial center sides thereof become low, are disposed in the form of plural layers so that the axial centers of the dielectric bars have planar regularities; a second high-frequency reflecting wall which is opposite to the first high-frequency reflecting wall in parallel with a dielectric interposed therebetween and wherein dielectric bars of predetermined lengths, which comprise a plurality of dielectric constant-different columnar bodies concentrically disposed so that their dielectric constants on the axial center sides thereof become low, are disposed in the form of plural layers so that the centers of the dielectric bars have planar regularities; and conductive plates which are opposite to each

other with the end faces of the dielectric bodies constituting the first and second high-frequency reflecting walls being interposed therebetween and which are respectively connected to both end faces of the dielectric bars constituting the first and second high-frequency reflecting walls.

Accordingly, the dielectric bars constitute a photonic crystal structure, and the first and second high-frequency reflecting walls reflect all of high-frequency waves lying in a predetermined frequency band, having electric field components orthogonal to the axial directions of the dielectric bars, whereby a high-frequency waveguide can be configured which is reduced in radiation loss and low in transmission loss. In its turn, a high-frequency waveguide low in transmission loss and inexpensive can be configured with a simple structure.

It is another object of the present invention to provide a method of manufacturing a high-frequency waveguide low in loss and simple in structure in a simple process.

According to another aspect of the invention, there is provided a method of manufacturing a high-frequency waveguide, including the steps of: laminating dielectric bars of predetermined lengths, comprising a plurality of dielectric constant-different columnar bodies concentrically disposed so that their dielectric constants become low on the axial center sides thereof, in the form of such plural layers that the centers of the dielectric bars have planar regularities to thereby form first and second high-frequency reflecting walls; and opposing the first and second high-frequency reflecting walls to each other in parallel, opposing conductive plates to each other with end faces of the dielectric bars constituting the first and second high-frequency reflecting walls being interposed therebetween, and connecting the conductive plates to both end faces of the dielectric bars constituting the first and

second high-frequency walls respectively.

Accordingly, a high-frequency waveguide reduced in radiation loss and low in transmission loss can be manufactured in a simple process. In its turn, a high-frequency waveguide good in transmission characteristic can be provided at low cost.

Other objects and advantages of the invention will become apparent from the detailed description given hereinafter. It should be understood, however, that the detailed description and specific embodiments are given by way of illustration only since various changes and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description.

**Brief Description of the Drawings**

Fig. 1 is a partially-through partly perspective view of a high-frequency waveguide according to an embodiment of the present invention;

Fig. 2 is a partly sectional view of the high-frequency waveguide according to an embodiment of the present invention as viewed from a section thereof taken along line II - II of Fig. 1;

Fig. 3 is a sectional view of the high-frequency waveguide according to an embodiment of the present invention as viewed from a section thereof taken along line III - III of Fig. 1;

Fig. 4 is a partially-through partly perspective view of a high-frequency waveguide according to an embodiment of the present invention ;

Fig. 5 is a partly sectional view of the high-frequency waveguide according to an embodiment of the present invention as viewed from a section thereof taken along line V - V of Fig. 4;

Fig. 6 is a sectional view of the high-frequency waveguide according to an embodiment of the present invention as

viewed from a section thereof taken along line VI - VI of Fig. 4

Fig. 7 is a perspective view of a conventional high-frequency waveguide;

Fig. 8 is a cross-sectional view of a conventional high-frequency waveguide as viewed from a section thereof taken along line VIII - VIII of Fig. 7;

Fig. 9 is a perspective view of a conventional high-frequency waveguide;

Fig. 10 is a partly sectional view of a conventional high-frequency waveguide as viewed from a section thereof taken along line X - X of Fig. 9;

Fig. 11 is a cross-sectional view of a conventional high-frequency waveguide as viewed from a section thereof taken along XI - XI of Fig. 9;

In all figures, the substantially same elements are given the same reference numbers.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

### First Embodiment

Fig. 1 is a partially-through partly perspective view of a high-frequency waveguide according to a first embodiment of the present invention. Fig. 2 is a partly sectional view of the high-frequency waveguide as viewed from a section thereof taken along line II - II of Fig. 1, and Fig. 3 is a sectional view of the high-frequency waveguide as viewed from a section thereof taken along line III - III of Fig. 1.

In Fig. 1, reference numeral 10 indicates a high-frequency waveguide, which is a waveguide using a photonic band crystal structure. This is a waveguide for allowing electromagnetic waves lying in micro-wave, millimeter-wave and submillimeter-wave bands to propagate therethrough. Reference numeral 12 indicates a first dielectric wall used as a first high-frequency reflecting wall, and reference numeral 14 indicates a second

dielectric wall used as a second high-frequency reflecting wall. The first dielectric wall 12 and the second dielectric wall 14 constitute the photonic band crystal structure.

Reference numeral 16 indicates a high-frequency propagation area interposed between the first dielectric wall 12 and the second dielectric wall 14 disposed in parallel with a predetermined interval defined therebetween. In the present embodiment, the high-frequency propagation area 16 is a simple space and filled with air 16a used as a dielectric. However, it may not always be the air 16a. If a material low in dielectric constant is used, then a high-frequency wave can be propagated with a low loss.

Reference numerals 18 indicate alumina cylindrical columns or columns used as dielectric bars corresponding to fundamental elements which constitute the first dielectric wall 12 and the second dielectric wall 14. In the present embodiment, each of the alumina cylindrical columns 18 comprises an air column 18a defined as its center and an alumina cylinder 18b which surrounds the outside thereof. A cylindrical column made up of a material lower than the alumina cylinder 18b in dielectric constant may be provided on the central side as an alternative to the air column 18a. Namely, a layer structure comprising a plurality of layers may be adopted wherein the outsides of central-side columns low in dielectric constant are concentrically surrounded with cylinders each formed of a material high in dielectric constant. Alternatively, a columnar body having another sectional shape, which is not always cylindrical, may be adopted.

In order to constitute the photonic band crystal structure by using the alumina cylindrical columns 18, the first dielectric wall 12 and the second dielectric wall 14 are arranged in a three-layer form so that the axial centers or

cores of the alumina cylindrical columns 18 constitute triangular lattice arrays respectively. As lattice intervals of the alumina cylindrical columns 18, a suitable value is determined according to the frequency of a high-frequency wave to be propagated. The lattice arrays do not necessarily require the triangular lattice arrays. Other lattice arrays such as a hexagonal lattice array, etc. may be used. The number of layers does not necessarily require the three. Further, the number of layers may be increased.

Reference numerals 20 indicate metal plates used as conductive or conductor plates, which are opposite to each other with the first dielectric wall 12 and the second dielectric wall 14 interposed therebetween. Further, the metal plates 20 are respectively bonded to the first dielectric wall 12 and the second dielectric wall 14 at both ends of the alumina cylindrical columns 18 which constitute the first dielectric wall 12 and the second dielectric wall 14. In Fig. 1, the metal plates 20 are hatched as being not intended to indicate their sections but indented to clearly define a relationship of position between the two metal plates 20 and the first and second dielectric walls 12 and 14. This is similar even in Fig. 4 to be described later.

Referring to Fig. 2, sizes a indicated by arrows indicate lattice intervals.

A summary of a method of manufacturing a high-frequency waveguide 10 will next be described.

Hollow alumina cylindrical columns 18 each having the same diameter as each of the lattice intervals a of a photonic band crystal structure, which corresponds to the wavelength of a high-frequency wave, and having a height equivalent to a predetermined interval between the metal plate 20 are prepared. The cores of the alumina cylindrical columns 18 are arranged in

shapes extending along the planar shape of each metal plate 20 of the high-frequency waveguide 10. An alumina cylindrical column array corresponding to a first layer is disposed in such a manner that the outer peripheries of the alumina cylindrical columns 18 are kept in close proximity to one another and both ends thereof are held in alignment with one another.

Next, when alumina cylindrical columns 18 used for or corresponding to a second layer are arranged so that they respectively make contact with the respective adjacent two alumina cylindrical columns 18 constituting the alumina cylindrical column array corresponding to the first layer at their outer peripheries together, the alumina cylindrical columns constituting the alumina cylindrical column array corresponding to the second layer also contact with one another. The two layers constitute at least a triangular lattice array.

Further, alumina cylindrical columns 18 corresponding to a third layer are arranged so that they respectively make contact with the respective adjacent two alumina cylindrical columns 18 constituting the alumina cylindrical column array corresponding to the second layer at their outer peripheries together, whereby alumina cylindrical column array corresponding to the third layer is formed. The alumina cylindrical column arrays corresponding to the first, second and third layers are bonded to one another with an adhesive. As a result, a first dielectric wall 12 is formed.

Next, a second dielectric wall 14 is formed according to a method similar to the above. A predetermined interval is defined between the first dielectric wall 12 and the second dielectric wall 14. Cylindrical end faces of alumina cylindrical columns 18 constituting the dielectric wall are disposed so as to make contact with the metal plate 20. The metal plate 20, the first dielectric wall 12 and the second dielectric wall 14 are bonded

to one another. Further, another metal plate 20 is opposed to the metal plate 20 with the first dielectric wall 12 and the second dielectric wall 14 interposed therebetween. Another metal plate 20 is also bonded to the first dielectric wall 12 and the second dielectric wall 14.

As to another manufacturing method, a high-frequency propagation area 16 is formed of a material like, for example, styrofoam low in dielectric constant. Hollow alumina cylindrical columns 18 prepared so as to contact both sides of the high-frequency propagation area 16 are arranged so that their outer peripheries are held in contact with one another, whereby an alumina cylindrical column array corresponding to a first layer is arranged.

Next, alumina cylindrical columns 18 used for or corresponding to a second layer are respectively arranged so as to contact the adjacent two alumina cylindrical columns 18 constituting the alumina cylindrical column array corresponding to the first layer at their outer peripheries together. Consequently, the alumina cylindrical columns constituting the alumina cylindrical column array corresponding to the second layer also result in an array of columns which are held in contact with one another, whereby a triangular lattice array is formed.

Further, alumina cylindrical columns 18 for a third layer are arranged so as to make contact with the adjacent two alumina cylindrical columns 18 constituting the alumina cylindrical column array corresponding to the second layer, whereby an alumina cylindrical column array corresponding to the third layer is formed.

Thus, the first dielectric wall 12 and the second dielectric wall 14 are formed along the high-frequency propagation area 16. The high-frequency propagation area 16, the

first dielectric wall 12, and the second dielectric wall 14 are shaped so as to take a predetermined waveguide shape and are fixedly secured to one another with an adhesive. Further, two more metal plates 20 are opposed to each other with the first dielectric wall 12 and the second dielectric wall 14 interposed therebetween. The metal plates 20 are bonded to the first dielectric wall 12 and the second dielectric wall 14.

Owing to the adoption of these manufacturing methods, the high-frequency waveguide less reduced in transmission loss can be fabricated according to a simple process.



Namely, since the arrangements of the alumina cylindrical columns 18 are arrayed to configure the photonic band crystal structure, a method of manufacturing it is simple. Since the interval between crystal lattices of the photonic band crystal structure is on the order of mm in micro, millimeter and sub-millimeter waves, there is no need to take advantage of a photoengraving technique and an etching technique as distinct from an optical photonic band crystal structure. Simply arranging the alumina cylindrical columns 18 periodically makes it possible to fabricate a photonic band crystal structure and easily manufacture a long-distance high-frequency waveguide which is several tens of centimeters or a few meters in long, for example, thereby allowing mass production.

The operation of the high-frequency waveguide 10 will next be described.

Horns are coupled to input/output portions of the high-frequency waveguide 10 so that a high-frequency wave is inputted and/or outputted.

The first dielectric wall 12 and the second dielectric wall 14 of the high-frequency waveguide 10 constitute the photonic band crystal structure wherein the hollow alumina cylindrical columns 18 are arranged in form of the triangular

lattice arrays. Thus, each high- frequency wave lying within a frequency band corresponding to the photonic band crystal structure is prohibited from propagating in the first dielectric wall 12 and the second dielectric wall 14. Since, however, the photonic band crystal structure is equivalent to a defective portion under its disordered state in the high-frequency propagation area 16, an inputted high-frequency wave is propagated through the high-frequency propagation area 16.

Namely, plane electromagnetic waves having electric field components orthogonal to the axial directions of the alumina cylindrical columns 18 are all reflected with respect to the high-frequency waves in the high-frequency band corresponding to the photonic band crystal structure. There is thus no other choice but to allow the high-frequency electromagnetic waves to propagate along the high-frequency propagation area 16. Since the high-frequency propagation area 16 is filled with a dielectric like air low in dielectric constant, a transmission loss becomes low even in a high-frequency band.

A conventionally-known I-type waveguide (tentatively named in this way) wherein dielectric bars in which the peripheries of cylindrical columns high in dielectric constant are surrounded with cylindrical columns low in dielectric constant, are arranged in a triangular lattice form, is compared with such a II-type waveguide (tentatively named in this way) as shown in the first embodiment, which constitutes a photonic band crystal structure with dielectric bars in which the peripheries of cylindrical columns low in dielectric constant are surrounded with cylindrical columns high in dielectric constant, as constituent elements. Thus, in the conventionally-configured I-type waveguide, a gap is made open to an E wave (whose orientation of electric field is identical to the axial direction of each dielectric bar). In other words, a frequency

band unintended for propagation exists. However, no gap is made open to an H wave (whose orientation of electric field corresponds to the direction orthogonal to the axial direction of each dielectric bar). Therefore, the transmission loss increases even if the I-type waveguide forms a high-frequency waveguide.

On the other hand, in the II-type waveguide described in the present embodiment, gaps are set up or made open to the E and H waves. Further, in the high-frequency waveguide 10, gaps are made open to the E and H waves at a given specific frequency corresponding to each of the lattice intervals of the photonic band crystal structure, and hence a high-frequency waveguide providing less transmission loss can be configured.

In the high-frequency waveguide according to the first embodiment as described above, the first dielectric wall 12 and the second dielectric wall 14 are configured with the dielectric bars like the hollow alumina cylindrical columns 18 as the basic elements. Further, the high-frequency propagation area 16 is formed of the material low in dielectric constant. Therefore, a high-frequency waveguide can be configured which is capable of being reduced in transmission loss, allowing mass production in a simple process and providing low cost and satisfactory transmission efficiency.

**Second Embodiment**

Fig. 4 is a partially-through partly perspective view of a high-frequency waveguide according to a second embodiment of the present invention. Fig. 5 is a partly sectional view of the high-frequency waveguide as viewed from a section thereof taken along line V - V of Fig. 4, and Fig. 6 is a sectional view of the high-frequency waveguide as viewed from a section thereof taken along line VI - VI of Fig. 4.

In Fig. 4, reference numeral 30 indicates a high-frequency

waveguide, reference numerals 32 indicate metal cylindrical column arrays used as metal walls respectively, and reference numerals 32a indicate metal cylindrical columns used as metal bars which constitute the metal cylindrical column arrays 32 respectively. The metal cylindrical column arrays 32 employed in the present embodiment are arranged outside a first dielectric wall 12 and a second dielectric wall 14 in such a manner that the metal cylindrical columns 32a identical in diameter and length to alumina cylindrical columns 18 take triangular lattice arrays together with the alumina cylindrical columns 18 corresponding to the outermost layers of the first dielectric wall 12 and the second dielectric wall 14.

A method of manufacturing the high-frequency waveguide 30 is basically identical to the method of manufacturing the high-frequency waveguide 10 according to the first embodiment. Upon forming each of the first dielectric wall 12 and the second dielectric wall 14, the metal cylindrical columns 32a may be provided by one layers so as to constitute the triangular lattice arrays together with the alumina cylindrical columns 18 corresponding to the outermost layers of the first and second dielectric walls 12 and 14.

The first dielectric wall 12 and second dielectric wall 14 provided on both sides of a high-frequency propagation area 16 prohibit the propagation of high-frequency waves lying within a frequency band corresponding to a photonic band crystal structure. Namely, plane electromagnetic waves having electric field components orthogonal to the axial directions of the alumina cylindrical columns 18 are all reflected with respect to the high-frequency waves in the frequency band corresponding to the photonic band crystal structure. There is thus no other choice but to allow the high-frequency electromagnetic waves to propagate along the high-frequency propagation area 16.

However, each of the high-frequency waves that propagate through the high-frequency propagation area 16, has components parallel to the axial direction of each alumina cylindrical column 18 as well as the electric field components lying in the direction orthogonal to the axis direction of each alumina cylindrical column 18. The components parallel to the axial direction of each alumina cylindrical column 18 pass through the hollow alumina cylindrical columns 18.

The metal cylindrical columns 32a reflect all the high-frequency components that pass through the alumina cylindrical columns 18. At this time, a current flows through each metal cylindrical column array 32, which result in a conductor loss. However, since it decreases with an increase in frequency, this becomes insignificant so far in the case of a high frequency.

While the metal cylindrical column arrays 32 have been used as the metal walls in the second embodiment, metal column arrays each having a cross-section shaped in other form may be used or plate-shaped metal walls may be adopted.

Namely, the high-frequency waveguide according to the second embodiment is provided with the low-loss waveguide walls which reflect even the electric field components parallel to the axial directions of the alumina cylindrical columns 18 constituting the photonic band crystal structure as well as the electric field components lying in the direction orthogonal to the axial direction of each of the alumina cylindrical columns 18. Consequently, a waveguide can be configured which is free of the leakage of a high-frequency wave and low in loss. In its turn, a high-frequency waveguide, which is low in cost and provides satisfactory transmission efficiency, can be constructed.

Since the high-frequency waveguide according to the present invention and the manufacturing method thereof have such

configurations as described above and include the steps as well, the following advantageous effects are brought about.

The high-frequency waveguide according to the present invention comprises a first high-frequency reflecting wall wherein dielectric bars of predetermined lengths, which respectively comprise a plurality of dielectric constant-different columnar bodies concentrically disposed so that their dielectric constants on the axial center sides thereof become low, are disposed in the form of plural layers so that the axial centers of the dielectric bars have planar regularities, a second high-frequency reflecting wall which is opposite to the first high-frequency reflecting wall in parallel with a dielectric interposed therebetween and wherein dielectric bars of predetermined lengths, which comprise a plurality of dielectric constant-different columnar bodies concentrically disposed so that their dielectric constants on the axial center sides thereof become low, are disposed in the form of plural layers so that the centers of the dielectric bars have planar regularities, and conductive plates which are opposite to each other with the end faces of the dielectric bodies constituting the first and second high-frequency reflecting walls interposed therebetween and which are respectively connected to both end faces of the dielectric bars constituting the first and second high-frequency reflecting walls. The dielectric bars constitute a photonic crystal structure. The first and second high-frequency reflecting walls reflect all of high-frequency waves lying in a predetermined frequency band, having electric field components orthogonal to the axial directions of the dielectric bars, whereby a high-frequency waveguide can be configured which is reduced in radiation loss and low in transmission loss. In its turn, a high-frequency waveguide low in transmission loss and inexpensive can be configured with a simple structure.

Further, the dielectric bars are shaped in the form of cylinders. The shapes of the dielectric bars corresponding to the constituent elements of the first and second high-frequency reflecting walls can be simplified. In its turn, a simpler and cheaper high-frequency waveguide can be configured.

Furthermore, the dielectric bars are shaped in hollow form. A material low in dielectric constant, on the axial center side of each dielectric bar is set up as air, so that the construction of the dielectric bar can be simplified. In its turn, a low-cost high-frequency waveguide can be configured with a simple structure.

Still further, since the dielectric lying between the first high-frequency reflecting wall and the second high-frequency reflecting wall is used as air, the transmission loss can be reduced with a simple structure. In its turn, an inexpensive high-frequency waveguide low in transmission loss can be configured with a simple structure.

Still further, metal walls are further provided outside the dielectric bars corresponding to the outermost layers of the first and second high-frequency reflecting walls. The metal walls are capable of reflecting high-frequency waves having electric field components parallel to the axial directions of the dielectric bars. In its turn, a high-frequency waveguide reduced in the leakage of the high-frequency wave and good in transmission efficiency can be configured.

Still further, the metal walls are made up of metal bar arrays in which metal bars identical in length to dielectric bars are disposed along the dielectric bars. Each of the metal walls can be brought to a simple configuration easy to lay out along each dielectric bar. In its turn, a high-frequency waveguide low in cost and good in transmission efficiency can be configured.

A method of manufacturing a high-frequency waveguide, according to the present invention, includes a step for laminating dielectric bars of predetermined lengths, comprising a plurality of dielectric constant-different columnar bodies concentrically disposed so that their dielectric constants become low on the axial central sides thereof, in the form of such plural layers that the centers of the dielectric bars have planar regularities to thereby form first and second high-frequency reflecting walls, and a step for opposing the first and second high-frequency reflecting walls to one another in parallel at predetermined intervals, opposing conductive plates to one another with end faces of the dielectric bars constituting the first and second high-frequency reflecting walls being interposed therebetween, and connecting the conductive plates to both end faces of the dielectric bars constituting the first and second high-frequency walls respectively. A high-frequency waveguide reduced in radiation loss and low in transmission loss can be manufactured in a simple process. In its turn, a high-frequency waveguide good in transmission characteristic can be provided at low cost.

The method further includes a step for forming metal walls outside the dielectric bars corresponding to the outermost layers of the first and second high-frequency reflecting walls. A high-frequency waveguide capable of reflecting each high-frequency wave having electric field components parallel to the axial directions of the dielectric bars can be manufactured in a simple process. In its turn, a high-frequency waveguide reduced in the leakage of the high-frequency wave and good in transmission characteristic can be provided at a low cost.

While the presently preferred embodiments of the present invention have been shown and described. It is to be understood these disclosures are for the purpose of illustration and that

various changes and modifications may be made without departing from the scope of the invention as set forth in the appended claims.